IN THE SPECIFICATION:

Please replace paragraph **[0021]** with the following amended paragraph:

[0021] Figure 1 illustrates a perspective and partial sectional view of an exemplary electrochemical plating cell 100 of the invention. The plating ~~Plating~~ cell 100 generally includes an outer basin 101 and an inner basin 102 positioned within the outer basin 101. The inner ~~Inner~~ basin 102 is generally configured to contain a plating solution that is used to plate a metal, e.g., copper, onto a substrate during an electrochemical plating process. During the plating process, the plating solution is generally continuously supplied to the inner basin 102 (at about 1 gallon per minute for a 10 liter plating cell, for example), and therefore, the plating solution continually overflows the uppermost point of the inner basin 102 and runs into the outer basin 101. The overflow plating solution is then collected by the outer basin 101 and drained therefrom for recirculation into the inner basin 102. As illustrated in Figure 1, the plating cell 100 is generally positioned at a tilt angle, i.e., ~~the~~ a frame member 103 of the plating cell 100 is generally elevated on one side such that the components of the plating cell 100 are tilted between about 3° and about 30°. Therefore, in order to contain an adequate depth of the plating solution within the inner basin 102 during plating operations, the uppermost portion of the inner basin 102 may be extended upward on one side of the plating cell 100, such that the uppermost point of the inner basin 102 is generally horizontal and allows for contiguous overflow of the plating solution supplied thereto around the perimeter of the inner basin 102.

Please replace paragraph **[0022]** with the following amended paragraph:

[0022] The frame member 103 of the plating cell 100 generally includes an annular base member 104 secured to the frame member 103. Since the frame member 103 is elevated on one side, the upper surface of the base member 104 is generally tilted from the horizontal at an angle that corresponds to the angle of the frame member 103 relative to a horizontal position. The base ~~Base~~ member 104 includes an annular or

disk shaped recess formed therein, the annular recess being configured to receive a disk shaped anode ~~member~~ 105. The anode ~~Anode~~ ~~member~~ 105 may be a soluble anode, such as a pure copper anode, a doped copper anode (doped with phosphorous, for example), or another soluble anode known in the plating art, or alternatively, an insoluble anode, such as a platinum anode, platinized titanium anode, or other inert or insoluble anode known in the plating art may be used. The base ~~Base~~ member 104 further includes a plurality of fluid inlets/drains 109 positioned on a lower surface thereof. Each of the fluid inlets/drains 109 are generally configured to individually supply or drain a fluid to or from either the anode compartment or the cathode compartment of the plating cell 100. The anode ~~Anode member~~ 105 generally includes a plurality of slots 107 formed therethrough, wherein the slots 107 are generally positioned in parallel orientation with each other across the surface of the anode 105. The parallel orientation allows for dense fluids generated at the anode surface to flow downwardly across the anode surface and into one of the slots 107. The plating ~~Plating~~ cell 100 further includes a membrane support assembly 106. The membrane ~~Membrane~~ support assembly 106 is generally secured at an outer periphery thereof to the base member 104, and includes an interior region 108 configured to allow fluids to pass therethrough via a sequence of oppositely positioned slots and bores. The membrane support assembly 106 may include an o-ring type seal positioned near a perimeter of the membrane support assembly 106, wherein the seal is configured to prevent fluids from traveling from one side of ~~the~~ a membrane 112 secured on the membrane support assembly 106 to the other side of the membrane 112.

Please replace paragraph **[0023]** with the following amended paragraph:

[0023] The membrane 112 generally operates to fluidly isolate the anode chamber from the cathode chamber of the plating cell 100. The membrane ~~Membrane~~ 112 is generally an ionic membrane. The ion ~~exchange~~ membrane generally includes fixed negatively charged groups, such as SO_3^-, COO^-, HPO_2^-, SeO_3^-, PO_3^{2-}, or other negatively charged groups amenable to plating processes. The membrane ~~Membrane~~ 112 allows a particular type of ions to travel through the membrane, while preventing

another type of ion from traveling or passing through the membrane 112. More particularly, the membrane 112 may be a cationic membrane that is configured to allow positively charged copper ions (Cu^{2+}) to pass therethrough, i.e., to allow copper ions to travel from the anode 105 in the anolyte solution through the membrane 112 into the catholyte solution, where the copper ions may then be plated onto the substrate. Further, the cationic membrane may be configured to prevent passage of negatively charged ions and electrically neutral species in the solution, such as the ions that make up the plating solution and catholyte additives. It is desirable to prevent these catholyte additives from traveling through the membrane 112 and contacting the anode 105, as the additives are known to break down upon contacting the anode 105. More particularly, membranes with negatively charged ion groups like SO_3^- etc. not only to facilitate Cu ions transport from the anolyte to the catolyte, but also to prevent penetration of accelerators to the anode 105. The accelerator is generally negatively charged organic ion: $^{-}SO_3^{-}$-C_3H_6-S-S-C_3H_6-SO_3^{-}, so it can't penetrate into or through the ~~cation~~ cationic membrane. This is important, as consumption of accelerators on copper anodes on conventional plating apparatuses without the ionic membrane is very high.

Please replace paragraph **[0028]** with the following amended paragraph:

[0028] Figure 2 illustrates a perspective view of base member 104. The upper surface of the base member 104 generally includes an annular recess region 201 configured to receive ~~a disk shaped~~ the anode 105 therein. Further, the surface of the annular recess region 201 generally includes a plurality of channels 202 formed therein. Each of the channels 202 are generally positioned in parallel orientation with each other and terminate at the periphery of the annular recessed region 201. Additionally, the periphery of the annular recess[[ed]] region 201 also includes an annular drain channel 203 that extends around the perimeter of the annular recess[[ed]] region 201. Each of the plurality of the parallel positioned channels 202 terminate at opposing ends into the annular drain channel 203. Therefore, the channels 202 may receive dense fluids from anode ~~channels~~ slots 302 and transmit the dense fluids to ~~a~~ the annular drain channel 203 via the ~~base~~ channels 202. The vertical wall that defines the annular recess[[ed]]

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region 201 generally includes a plurality of slots 204 formed into the wall. The slots 204 are generally positioned in parallel orientation with each other, and further, are generally positioned in parallel orientation with the plurality of the channels 202 formed into the lower surface of the annular recess[[ed]] region 201. The base ~~Base~~ member 104 also includes at least one fluid supply conduit 205 configured to dispense a fluid into the anode region of the plating cell 100, along with at least one plating solution supply conduit 206 that is configured to dispense a plating solution into the cathode compartment of the plating cell 100. The respective supply conduits 205 and 206 are generally in fluid communication with at least one fluid ~~supply line~~ inlets/drains 109 positioned on a lower surface of the base member 104, as illustrated in Figure 1. The base ~~Base~~ member 104 generally includes a plurality of conduits formed therethrough (not shown), wherein the conduits are configured to direct fluids received by individual fluid ~~supply lines~~ inlets/drains 109 to the respective cathode and anode chambers of the plating cell 100.

Please replace paragraph **[0029]** with the following amended paragraph:

[0029] Figure 3 illustrates a perspective view of the base member 104 having the disk shaped anode 105 positioned therein. The anode ~~Anode~~ 105, which is generally a disk shaped copper member, *i.e.*, a soluble-type copper anode generally used to support copper electrochemical plating operations, generally includes a plurality of the anode slots 302 formed therein. The anode slots 302 generally extend through the interior of the anode ~~302~~ 105 and are in fluid communication with both the upper surface and lower surface of the anode 105. As such, the anode slots 302 allow fluids to travel through the interior of the anode 105 from the upper surface to the lower surface. The anode slots ~~Slots~~ 302 are positioned in parallel orientation with each other. However, when the anode 105 is positioned within the annular recess region 201 of the base member 104, the parallel anode slots 302 of the anode 105 are generally positioned orthogonal to both the slots 204 and the channels 202 of the base member 104, as illustrated cooperatively by Figures 2 and 3. Additionally, the anode slots 302 generally do not continuously extend across the upper surface of the anode 105. Rather, the anode slots 302 are broken into a longer segment 303 and a shorter segment 304, with

a space 305 between the two segments, which operates to generate a longer current path through the anode 105 from one side to the other. Further, adjacently positioned anode slots 302 have the space 305 positioned on opposite sides of the anode upper surface. The current path from the lower side of the anode 105 to the upper side of the anode 105 generally includes a back and forth type path between the respective ~~channels~~ anode slots 302 through the spaces 305. Further, the positioning of the spaces 305 and ~~channels~~ the anode slots 302 provides for improved concentrated Newtonian fluid removal from the surface of the anode 105, as the positioning of ~~channels~~ the anode slots 302 provides a shortest possible distance of travel for the dense fluids to be received in ~~channels~~ the anode slots 302. This feature is important, as dense fluids generally travel slowly, and therefore, it is desirable.

Please replace paragraph **[0030]** with the following amended paragraph:

[0030] Figure 4 illustrates an exploded perspective view of an exemplary membrane support assembly 106 of the invention. The membrane ~~Membrane~~ support assembly 106 generally includes an upper ring shaped support member 401, an intermediate membrane support member 400, and a lower support member 402. The upper ~~Upper~~ and lower support members ~~member's~~ 401 and 402 are generally configured to provide structural support to the intermediate membrane support member 400, *i.e.*, the upper support member 401 operates to secure the intermediate membrane support member 400 to the lower support member 402, while the lower support member 402 receives the intermediate membrane support member 400. The intermediate ~~Intermediate~~ membrane support member 400 generally includes a substantially planar upper surface having a plurality of bores partially formed therethrough. A lower surface of the intermediate membrane support member 400 generally includes a tapered outer portion 403 and a substantially planar inner membrane engaging surface [[404]] 406. An upper surface of the lower support member 402 may include a corresponding tapered portion configured to receive the tapered outer portion 403 of the intermediate membrane support member 400 thereon. The membrane engaging surface [[404]] 406 generally includes a plurality of parallel positioned/orientated channels (not shown). Each of the channels formed into the lower surface of the intermediate membrane

support member 400 are in fluid communication with at least one of the plurality of bores partially formed through the planar upper surface of the intermediate membrane support member 400. The channels operate to allow ~~a~~ the membrane 112 positioned in the membrane support assembly 106 to deform slightly upward in the region of the channels, which provides a flow path for air bubbles and less dense fluids in the cathode chamber to travel to the perimeter of the membrane 112 and be evacuated from the anode chamber.

Please replace paragraph **[0032]** with the following amended paragraph:

[0032] Assuming a tilted implementation is utilized, a substrate is first immersed into a plating solution contained within the inner basin 102. Once the substrate is immersed in the plating solution, which generally contains copper sulfate, chlorine, and one or more of a plurality of organic plating additives (levelers, suppressors, accelerators, etc.) configured to control plating parameters, an electrical plating bias is applied between a seed layer on the substrate and the anode 105 positioned in a lower portion of the plating cell 100. The electrical plating bias generally operates to cause metal ions in the plating solution to deposit on the cathodic substrate surface. The plating solution supplied to the inner basin 102 is continually circulated through the inner basin 102 via the fluid ~~inlet/outlets~~ inlets/drains 109. More particularly, the plating solution may be introduced in the plating cell 100 via ~~a~~ the fluid inlets/drains 109. The solution may travel across the lower surface of the base member 104 and upward through one of the fluid apertures/conduits 206. The plating solution may then be introduced into the cathode chamber via a channel formed into the plating cell 100 that communicates with the cathode chamber at a point above the membrane support assembly 106. Similarly, the plating solution may be removed from the cathode chamber via a fluid drain positioned above the membrane support assembly 106, where the fluid drain is in fluid communication with one of the fluid inlets/drains 109 positioned on the lower surface of the base member 104. For example, the base member 104 may include first and second fluid apertures 206 positioned on opposite sides of the base member 104. The oppositely positioned fluid apertures 206 may operate to individually

introduce and drain the plating solution from the cathode chamber in a predetermined direction, which also allows for flow direction control. The flow control direction provides control over removal of light fluids at the lower membrane surface, removal of bubbles from the anode chamber, and assists in the removal of dense or heavy fluids from the anode surface via the channels 202 formed into the base member 104.

Please replace paragraph **[0033]** with the following amended paragraph:

[0033] Once the plating solution is introduced into the cathode chamber, the plating solution travels upward through a diffusion plate 110. The diffusion ~~Diffusion~~ plate 110, which is generally a ceramic or other porous disk shaped member, generally operates as a fluid flow restrictor to even out the flow pattern across the surface of the substrate. Further, the diffusion plate 110 operates to resistively damp electrical variations in the electrochemically active area, the anode or cation membrane surface, which is known to reduce plating uniformities. Additionally, embodiments of the invention contemplate that the ceramic diffusion plate 110 may be replaced by a hydrophilic plastic member, *i.e.*, a treated PE member, an PVDF member, a PP member, or other material that is known to be porous and provide the electrically resistive damping characteristics provided by ceramics. However, the plating solution introduced into the cathode chamber, which is generally a plating catholyte solution, *i.e.*, a plating solution with additives, is not permitted to travel downward through the membrane 112 ~~(not shown)~~ positioned on the lower surface 404 of the membrane support assembly 106 into the anode chamber, as the anode chamber is fluidly isolated from the cathode chamber by the membrane 112. The anode chamber includes separate individual fluid supply and drain sources configured to supply ~~a~~ an anolyte solution to the anode chamber. The solution supplied to the anode chamber, which may generally be copper sulfate in a copper electrochemical plating system, circulates exclusively through the anode chamber and does not diffuse or otherwise travel into the cathode chamber, as the membrane 112 positioned on the membrane support assembly 106 is not fluid permeable in either direction.

Please replace paragraph **[0034]** with the following amended paragraph:

[0034] Additionally, the flow of the fluid solution (anolyte, *i.e.*, a plating solution without additives, which may be referred to as a virgin solution) into the anode chamber is directionally controlled in order to maximize plating parameters. For example, anolyte may be communicated to the anode chamber via an individual fluid inlet of the fluid inlets/drains 109. The individual fluid ~~Fluid~~ inlet ~~109~~ is in fluid communication with a fluid channel formed into a lower portion of the base member 104 and the fluid channel communicates the anolyte to one of ~~apertures~~ fluid supply conduits 205. A seal positioned radially outward of ~~apertures~~ the fluid supply conduits 205, in conjunction with the surrounding structure, directs the anolyte flowing out of ~~apertures~~ the fluid supply conduits 205 upward and into the slots 204 (also termed channels). Thereafter, the anolyte generally travels across the upper surface of the anode 105 towards the opposing side of the base member 104, which in a tilted configuration, is generally the higher side of the plating cell 100. The anolyte travels across the surface of the anode 105 below the membrane 112 positioned immediately above. Once the anolyte reaches the opposing side of the anode 105, it is received into a corresponding fluid channel ~~204~~ and drained from the plating cell 100 ~~104~~ for recirculation thereafter.

Please replace paragraph **[0035]** with the following amended paragraph:

[0035] During plating operations, the application of the electrical plating bias between the anode 105 and the cathode generally causes a breakdown of the anolyte solution contained within the anode chamber. More particularly, the application of the plating bias operates to generate multiple hydrodynamic or Newtonian layers of the copper sulfate solution within the anode chamber. The hydrodynamic layers generally include a layer of concentrated copper sulfate positioned proximate the anode 105, an intermediate layer of normal copper sulfate, and a top layer of lighter and depleted copper sulfate proximate the membrane. The depleted layer is generally a less dense and lighter layer of copper sulfate than the copper sulfate originally supplied to the anode compartment, while the concentrated layer is generally a heavier and denser

layer of copper sulfate having a very viscous consistency. The dense consistency of the concentrated layer proximate the anode causes electrical conductivity problems (known as anode passivation) in anodes formed without the anode slots 302. However, the anode slots 302, in conjunction with the tilted orientation of the plating cell 100, operate to receive the concentrated viscous layer of copper sulfate and remove the layer from the surface of the anode, which eliminates conductivity variances. Further, the plating cell 100 generally includes one side that is tilted upward or vertically positioned above the other side, and therefore, the surface of the anode 105 is generally a plane that is also tilted. The tilt causes the layer of concentrated copper sulfate generated at the surface of the anode to generally flow downhill as a result of the gravitational force acting thereon. As the concentrated copper sulfate layer flows downhill, it is received within one of the anode slots 302 and removed from the surface of the anode 105. As discussed above, the anode slots 302 are generally parallel to each other and are orthogonal to ~~channels~~ the slots 204. Therefore, the anode slots 302 are also orthogonal to the channels 202 formed into the lower surface of the base member 104. As such, each of the anode slots 302 ~~or~~ finally intersects several of the channels 202. This configuration allows the concentrated copper sulfate received within the anode slots 302 to be communicated to one or more of the channels 202. Thereafter, the concentrated copper sulfate may be communicated via the channels 202 to the annular drain 203 positioned within the recessed portion 201. The drain 203 in communication with the channels 202 may generally be communicated through the base ~~plate~~ member 104 and back to a central anolyte supply tank, where the concentrated copper sulfate removed from the anode surface may be recombined with a volume of stored copper sulfate used for the anolyte solution.

Please replace paragraph **[0036]** with the following amended paragraph:

[0036] Similarly, the upper portion of the anode chamber generates a diluted layer of copper sulfate proximate the membrane. The diluted layer of copper sulfate may be removed from the anode chamber via an air vent 501, as illustrated in Figure 5. Air vent/drain 501, which may include multiple ports, is generally positioned on the

upper side of the electrochemical plating cell 100, and therefore, is positioned to receive both bubbles trapped within the anode chamber, as well as the diluted copper sulfate generated at the membrane surface. The air ~~Air~~ vents 501 are generally in fluid communication with the anolyte tank discussed above, and therefore, communicates the diluted copper sulfate received therein back to the anolyte tank, where the diluted copper sulfate may combine with the concentrated copper sulfate removed via the anode slots 302 to form the desired concentration of copper sulfate within the anolyte tank. Any bubbles trapped by the air vent 501 may also be removed from the cathode chamber vented to atmosphere or simply maintained within the anolyte tank and not recirculated into the cathode chamber.